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Yields and Composition of Holocellulose Prepared from Various Feeds and Feces. 1/

Ray E. Ely
Dairy Husbandry Research Branch, Agricultural Research Service,
USDA, Beltsville, Maryland

Studies of holocellulose prepared from common forages are quite limited. Since the cellulose and hemicellulose fractions represent the major part of most forage materials and contribute substantially to the energy value of forages for ruminants it was thought desirable to study the possibility of separating these polysaccharides from forage in a single fraction (holocellulose). Comparable digestibilities of cellulose and hemicellulose by ruminants justify combining these fractions from a physiological viewpoint.

The objectives of this study were to (a) find a satisfactory delignification treatment for the preparation of holocellulose that would retain all of the cellulose and hemicellulose fractions from a variety of forages, (b) ascertain if a uniform delignification treatment would be suitable for the preparation of holocellulose from forages varying widely in composition, (c) calculate the recoveries of theoretical holocellulose in holocellulose preparations from various forages, and (d) determine the yields and composition of holocellulose prepared from the feces of animals fed these forages.

Experimental Procedure

Ten forages that varied widely in the amounts of the various constituents as determined by proximate analyses were chosen. The forages used consisted of 7 hays, 2 silages, and one straw. The feces used were collected from animals receiving these forages as their entire ration.

Holocellulose was prepared according to the procedure outlined by Wise, Murphy and D'Addieco 2/ with minor modifications.

1/ Paper presented at the annual meeting of the American Dairy Science Association, State College, Pa., June 21-24, 1954.

2/ Wise, Murphy and D'Addieco. Paper Trade J. 122:35, 1946

The theoretical holocellulose contents of the various materials were calculated as the lignin and protein-free organic matter of the "extractive-free" dry matter, according to the following formula:

Theoretical Holocellulose = 100-(ash + protein + lignin) 3/

Results and Discussion

The proximate composition and the lignin contents of the 10 feeds studied are presented in Table 1.

Table 1.- Composition of the dry matter of feeds

	Protein	Ether Extract	Crude Fiber	N.F.E.	Ash	Lignin
	%	%	%	%	%	%
Soybean Hay.....	11.0	0.9	42.9	36.7	8.5	13.5
Wheat Straw.....	3.2	1.4	42.4	48.1	4.9	13.0
Clover Hay.....	10.7	1.7	37.8	43.6	6.2	12.7
Mature Orchard Grass..	11.1	2.3	35.1	46.3	5.2	9.3
Timothy Hay.....	6.7	1.9	34.2	52.9	4.3	10.7
Alfalfa Hay.....	14.5	1.5	31.7	45.0	7.3	10.0
Lespedeza Hay.....	13.8	3.0	30.5	45.5	7.2	12.6
Young Orchard Grass..	22.0	3.0	24.1	44.4	5.8	5.5
Alfalfa Silage.....	17.8	3.0	37.9	32.3	9.0	12.5
Corn Silage.....	7.4	2.3	22.7	63.2	4.4	6.9

The composition (protein, ash, lignin) of the dry matter of the "extractive-free" feeds is given in Table 2. These analyses were used for the calculations of the theoretical holocellulose contents of the various feeds which also are given in Table 2.

3/ Ash, protein and lignin as % "extractive-free" dry matter.

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Table 2.- Composition of the dry matter of "extractive-free" feeds 1/

	Protein	Ash	Lignin	Theoretical Holocellulose
	%	%	%	%
Soybean Hay.....	9.2	4.5	16.6	69.7
Wheat Straw.....	2.1	3.1	13.4	81.4
Clover Hay.....	10.5	2.8	15.5	71.2
Mature Orchard Grass..	9.4	1.9	11.3	77.4
Timothy Hay.....	5.9	2.0	13.1	78.0
Alfalfa Hay.....	14.4	2.4	15.4	67.8
Lespedeza Hay.....	14.3	3.8	15.8	66.1
Young Orchard Grass...	22.5	1.7	7.4	68.4
Alfalfa Silage.....	10.8	2.7	17.1	69.4
Corn Silage.....	5.4	1.3	12.2	81.1

1/ Residue after extraction of alcohol-benzene and hot water soluble materials.

Orienting experiments with four feeds (corn silage, wheat straw, young orchard grass, and alfalfa silage) were conducted to study the effect of repeated acid chlorite treatments on the yields and composition of the prepared holocellulose samples.

Table 3 shows the yields of holocellulose obtained from each of the four feeds with each of six acid chlorite treatments. These results indicate that two acid chlorite treatments retain essentially all of the holocellulose in these four feeds. Recoveries of from 97 to 103% of the theoretical holocellulose are considered satisfactory.

The yields of crude holocellulose prepared from these feeds and the ash, protein, and lignin-free holocellulose contents are presented in figure 1. The lignin and nitrogen x 6.25 contents of the ash-free crude holocellulose prepared from the four feeds are also presented in figure 1. Delignification apparently occurred most rapidly during the first two or three treatments and at a slower rate with subsequent treatments.

The nitrogen content of crude holocellulose was highest when forage of high nitrogen content was delignified by acid chlorite treatment.

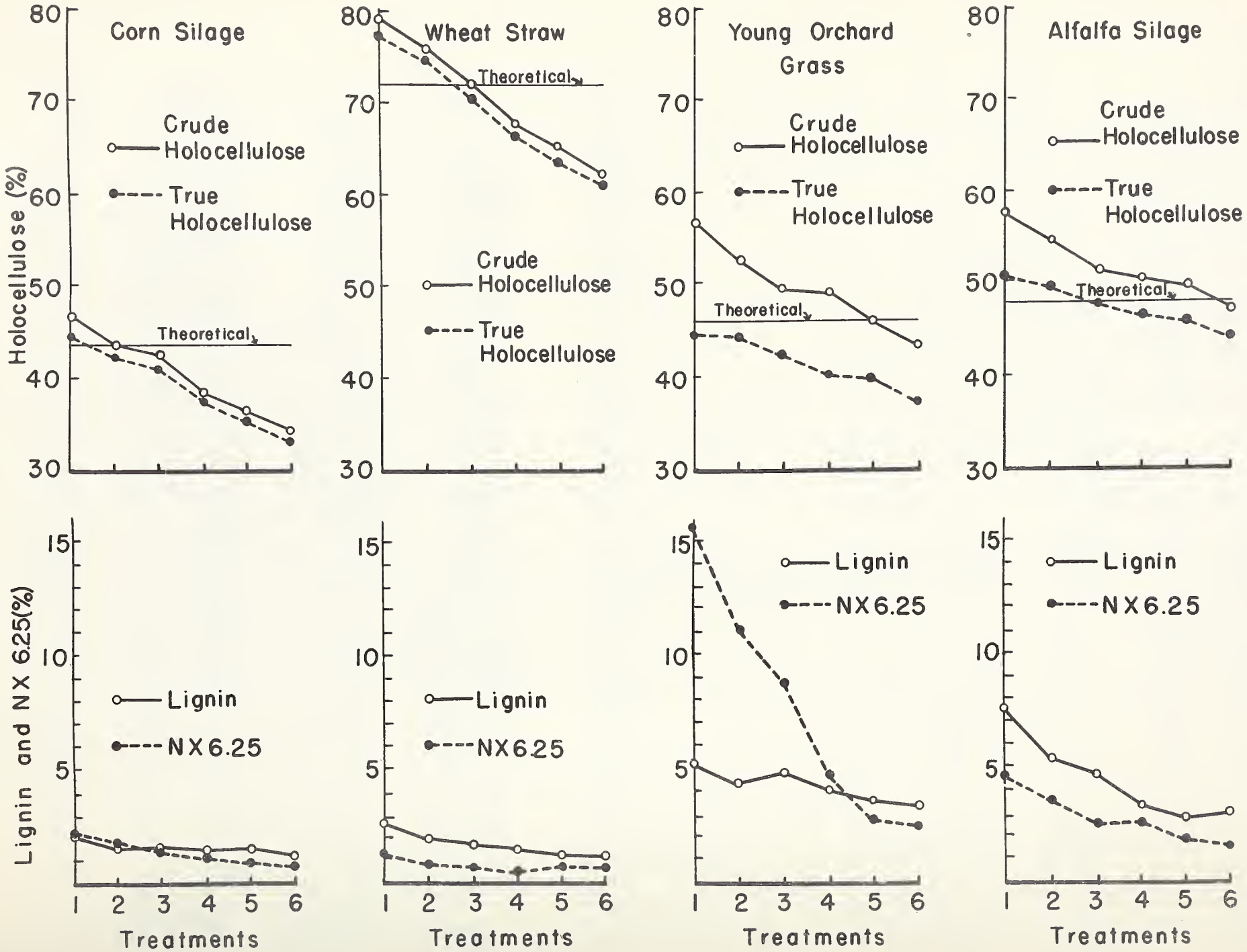

Figure 1. - Yields of Holocellulose from four forages and the lignin and nitrogen contents of the crude holocellulose prepared with various acid chlorite treatments.

Pretreatment of the forage sample with pepsin digestion before the acid chlorite treatment results in considerable reduction of the nitrogen retained in the prepared holocellulose but concurrent decreases in the recoveries of holocellulose occur.

The data in Table 3 and figure 1 indicate that two acid chlorite delignification treatments may be suitable for satisfactory recoveries of holocellulose from a variety of feeds with large differences in composition.

Table 3.- Yields of holocellulose 1/ obtained from four feeds using one to six delignification treatments

Treatments	Corn Silage	Wheat Straw	Young Orchard Grass	Alfalfa Silage	Average
1	102	107	97	106	103
2	97	103	97	103	100
3	95	102	93	100	98
4	86	92	89	97	91
5	82	88	85	96	88
6	77	85	81	93	84

1/ Figures given are yields of ash, protein and lignin-free holocellulose as percentage of the theoretical.

Holocellulose yields were determined with ten feeds by preparation with 1, 2, and 3 acid chlorite delignification treatments with each forage. The true holocellulose contents (ash, protein, and lignin-free) calculated as the percent of the theoretical holocellulose from each of these feeds with each treatment are presented in Table 4. Average recoveries of the theoretical holocellulose were 101, 99, and 96%, from the ten forages when using 1, 2, and 3 acid chlorite treatments, respectively. Two acid treatments with the conditions of this experiment are proposed as satisfactory for recoveries of approximately all of the cellulose and hemicellulose in one fraction (holocellulose) from a variety of feeds. These results indicate that a uniform acid chlorite delignification treatment may be used with feeds varying widely in composition. Further studies should provide a basis for improved procedures for the preparation of holocellulose from forage plants. The method used in this investigation has not been modified to provide what may be optimum conditions for the preparation of satisfactory holocellulose from the materials studied.

Table 4.- Yields of holocellulose obtained with 1, 2 and 3 acid chlorite delignification treatments

Treatments	Holocellulose[a] yield as % of theoretical		
	1	2	3
Soybean Hay	98	99	97
Wheat Straw	107	103	102
Clover Hay	99	99	95
Mature Orchard Grass	102	98	94
Timothy Hay	100	97	94
Alfalfa Hay	100	98	93
Lespedeza Hay	98	97	92
Young Orchard Grass	97	97	93
Alfalfa Silage	106	103	100
Corn Silage	102	97	95
Average	101	99	96

a/ Ash, lignin and protein-free holocellulose.

The holocellulose fraction represents from 66 to 81% of the dry matter of the "extractive-free" feeds studied. This fraction would ordinarily be distributed between the crude fiber and nitrogen-free extract fractions by the conventional proximate system of analyses. Holocellulose preparations that retain all of the carbohydrate material in "extractive-free" feeds should make an excellent starting material for studies of the content of alpha cellulose, hemicellulose, hemicellulose fractions, and the components of each of these fractions from various forages.

Summary

Acid chlorite delignification of ten forages varying widely in composition gave an average of 99% (97-103%) recovery of the theoretical holocellulose when two treatments were used.

Holocellulose contents of the feeds studied ranged from 66.1 to 81.4% of the "extractive-free" feed dry matter.

Two acid chlorite treatments gave recoveries of essentially all of the cellulose and hemicelluloses but did not give minimum lignin and nitrogen contents of the prepared holocellulose.

Excessive acid chlorite treatment resulted in apparent loss of carbohydrates from the holocellulose fraction.

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